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CLAIMS

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1. An automated telescope system comprising:

a telescope configured for rotation about two orthogonal axes;

a signal bus, configured to pass data and control signals between and among peripheral devices connected thereto;

a central control processor coupled to the signal bus, the control processor communicating data and control signals between and among peripheral devices coupled to the signal bus;

first and second motor assemblies, each motor assembly including:

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an electric motor coupled to move the telescope about one of the two orthogonal axes;

a control circuit coupled to the motor and to the signal bus, the control circuit developing control signals for commanding motor movement; and

a position indication circuit coupled to a respective axis and to the control circuit, the position indication circuit providing position indication signals to the respective control circuit;

wherein, the control circuit commands motor movement and evaluates motor position indication signals in operative response to control signals received from the central control processor.

2. The automated telescope system according to claim 1, wherein the central control processor performs high level application software execution tasks and numerical processing in order to define appropriate motor motion commands, the central control processor providing said motor motion commands to each control circuit over said signal bus, each control circuit

developing control signals for commanding motor movement in operative response thereto.

3. The automated telescope system according to claim 2, wherein each control circuit includes means for acquiring, storing and recalling motor position information for its respective motor. B

4. The automated telescope system according to claim 3, wherein the position indication circuit comprises an optical encoder, coupled to its respective motor shaft, the optical encoder developing electronic pulses, each pulse indicating a finite arcuate movement of the encoder, thereby indicating a finite arcuate movement of its respective motor.

5. The automated telescope system according to claim 4, wherein the signal bus is a serial bus, the central control processor communicating with each control circuit over a respective 2-wire serial connection in accordance with a packet communication protocol.

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6. An automated telescope system of the type including a telescope mounted for rotation about two substantially orthogonal axes, the automated telescope system comprising:

first and second motor assemblies, each coupled to rotate the telescope about a respective one of the axes, each motor assembly including:

a motor having a rotatable shaft;

an optical encoder coupled to the motor shaft for providing motor movement feedback information; and

a motor control processor for commanding motor movement and evaluating optical encoder feedback information; and

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a command unit connected to each motor assembly over a respective serial communication bus, the command unit receiving telescope movement commands from a user and developing appropriate control signals for communication to the motor control processor.

7. The automated telescope system according to claim 6, the command unit further comprising:

a housing configured to be comfortably hand held;

a keypad, disposed on the housing for manipulation by a user to define telescope movement commands; and

a microcontroller, disposed within the housing, the microcontroller translating user manipulation of the keypad into control signals, the control signals directed to each motor assembly over the serial communication bus.

8. The automated telescope system according to claim 7, the command unit further comprising:

a memory; and

a microprocessor, wherein the memory is adapted to host application software program code, executable by the microprocessor, the microprocessor performing high level application software execution tasks and numerical processing in order to define commands to the microcontroller, the microcontroller translating said commands into control signals for each motor assembly.

9. The automated telescope system according to claim 8, further comprising:

a first database, contained in memory, the first database including a catalog of celestial objects, each identified by a set of celestial coordinates; and

a second database, contained in memory, the second database including a catalog of geographical locations, each identified by a set of earth-based coordinates.

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10. The automated telescope system according to claim 9, a user identifying a geographical location from the second database, proximate to the user's actual location, wherein the command unit includes program means for translating earth-based coordinates into celestial coordinates.

11. The automated telescope system according to claim 10, wherein the command unit includes means for receiving telescope position indications from each motor assembly, the command unit processing the position indications in combination with the geographical location in order to define the telescope's orientation with respect to the celestial coordinate system.

12. The automated telescope system according to claim 11, wherein the command unit includes means for automatically traversing the telescope to a desired celestial object and for tracking the celestial path of said celestial object without further intervention by a user.

13. The automated telescope system according to claim 12, wherein the telescope is provided in an alt-azimuth configuration.

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14. The automated telescope system according to claim 13, wherein the telescope is provided in a polar configuration.

~~15. The automated~~ telescope system according to claim 7, the housing including an LCD display ~~screen, the~~ display screen

illuminated by a light source providing uniform illumination to the screen, the light source comprising:

a cusped, curvilinear light box positioned within the housing and beneath the display screen, the cusp bisecting the light box and disposed substantially midway between opposing ends of the light box; and

a plurality of light sources configured to shine into the light box in the direction of the cusp, wherein each arcuate portion of the cusp diffuses light and directs it onto the display screen at a substantially constant scattering angle with respect to the light sources.

16. The automated telescope system according to claim 15, wherein the light sources are light-emitting-diodes.

17. The automated telescope system according to claim 16, wherein the light box is constructed of a translucent material.

18. The automated telescope system according to claim 6, the serial communication bus further comprising:

an interface panel;

a pair of motor control buses, each coupled between the interface panel and a respective motor assembly;

a command unit bus, coupled between the interface panel and the command unit; and

an auxiliary bus, coupled to the interface panel and configured to promote data and control signal communication between the command unit and a plurality of peripheral devices serially coupled to the auxiliary bus.

19. The automated telescope system according to claim 18, wherein peripheral devices coupled to the serial bus are selected from a group consisting of a global positioning system

device, a time keeping device, an electronic compass, an MR sensor, a personal computer and an additional command unit.

20. A fully automated telescope system with functional intelligence distributed between independent components, the telescope system of the type including a telescope mounted for rotation about two substantially orthogonal axes, the automated telescope system comprising:

an intelligent motor module, the motor module including means for commanding a motor to rotate the telescope a desired arcuate amount about a respective axis, and further including means for determining the actual arcuate amount of rotation;

a command module, including means for translating a user input into signals suitable for transmission to the motor module, the motor module processing said signals into motor motion commands; and

a communication bus coupled between the command module and the motor module.

21. The fully automated telescope system according to claim 20, further comprising:

first means for determining a horizontal aspect of the telescope;

second means for determining a vertical aspect of the telescope; and

wherein the first and second means provide signals corresponding to each determined aspect to the command module.

22. The fully automated telescope system according to claim 21 further comprising:

means for defining a geographical position of the telescope; and

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means for processing the geographical position, the horizontal aspect and the vertical aspect of the telescope in order to orient the telescope with respect to a celestial coordinate system.

23. The fully automated telescope system according to claim 22, further comprising means for selecting a desired celestial object, wherein the telescope system automatically traverses to that object without further intervention by a user.

24. The fully automated telescope system according to claim 22, further comprising means for automatically inputting a time parameter.

25. The fully automated telescope system according to claim 21, wherein the first means comprises an MR sensor, configured to provide an indication signal when the telescope is pointing in a particular direction relative to a predefined compass point.

26. The fully automated telescope system according to claim 25, wherein the MR sensor is coupled to the communication bus, the MR sensor providing indication signals to the command module, the command module translating said indication signals into motor control signals suitable for transmission to the motor module, the motor module processing said motor control signals into motor motion commands, such that the telescope is automatically positioned in the particular direction relative to the predefined compass point in operative response to the indication signals.

27. In a computerized telescope system of the type including a telescope coupled for rotation about two orthogonal axes, a method for orienting the telescope system with respect to a spherical coordinate system, the method comprising:

providing a pair of motors, each coupled to rotate the telescope about a respective one of the orthogonal axes, each motor including a positional reference indicator, each positional reference indicator defining an arcuate position of the telescope with respect to its respective axis;

providing a control processor, the processor connected to receive positional reference information from each positional reference indicator;

inputting a time indicia to the control processor;

inputting a date indicia to the control processor;

moving the telescope about a first one of the axes to a first reference position;

recording positional reference data from the respective positional reference indicator as a first positional index;

moving the telescope about the second of the axes to a second reference position;

recording positional reference data from the respective positional reference indicator as a second positional index; and

processing the first and second positional indices and the time and date indicia so as to define a virtual coordinate location of the telescope system with respect to the spherical coordinate system.

28. The method according to claim 27, further comprising:

identifying, to the control processor, a spherical coordinate of a desired viewing object, the control processor calculating a set of respective positional reference indicia for each motor such that when the respective positional reference indicators are at said indicia, the telescope is pointing substantially at said desired viewing object; and

commanding the telescope system to actuate the motors so as to point the telescope at the desired object.

29. The method according to claim 28, further comprising:

reading a first set of positional reference data from the respective positional reference indicators when the telescope is pointing at the desired viewing object;

evaluating the position of the desired viewing object in a viewing field of the telescope;

actuating the motors so as to position the desired viewing object in a central region of the viewing field;

recording a second set of positional reference data from the respective positional reference indicators when the desired viewing object is positioned in the central region of the viewing field; and

processing the first and second sets of positional reference data so as to refine the virtual coordinate location of the telescope system with respect to the spherical coordinate system.

30. The method according to claim 29, wherein the spherical coordinate system is the celestial coordinate system.

31. The method according to claim 30, wherein the orthogonal telescope axes define an alt-azimuth mount configuration.

32. The method according to claim 31, wherein the position reference indicators comprise encoders coupled to their respective axes, each encoder defining an arcuate displacement of the telescope about its respective axis, the arcuate displacement based on the respective first or second positional index.

33. The method according to claim 32, wherein the first reference position is a determinable angle with respect to North,

and wherein the second reference position is a determinable angle with respect to horizontal.

34. The method according to claim 33, wherein the first reference position is substantially North, and wherein the second reference position is substantially horizontal.

35. In a computerized telescope system of the type including a telescope coupled for rotation about two orthogonal axes, the orthogonal axes defining a first coordinate system, a method for orienting the telescope system with respect to a spherical coordinate system, the method comprising:

providing first and second motors, each motor coupled to rotate the telescope about a respective one of the orthogonal axes;

providing first and second arcuate position indicators, each position indicator coupled to a respective one of the first and second motors, each position indicator indicating an arcuate position of the telescope with respect to its respective axis in the first coordinate system;

providing a control processor, the processor coupled to receive arcuate positions from the arcuate position indicators;

moving the telescope about a first one of the axes to a first reference position;

recording a first arcuate position corresponding to said first reference position of said first axis;

moving the telescope about a second one of the axes to a second reference position;

recording a second arcuate position corresponding to said second reference position of said second axis;

processing the first and second recorded arcuate positions so as to translate the telescope position in the first

coordinate system to a virtual telescope position in the spherical coordinate system; and

inputting a rotation metric, the rotation metric rotating the virtual telescope position in the spherical coordinate system in accord with a major axis of the spherical coordinate system.

36. The method according to claim 35, further comprising:

identifying the first and second recorded arcuate positions as respective first and second reference positions, one for each axis;

identifying, to the control processor, a spherical coordinate of a desired viewing object, the control processor translating said spherical coordinate into a set of desired arcuate positions with respect to the first and second reference positions, such that when each respective position indicator is at the respective desired arcuate position, the telescope is pointing substantially at said desired viewing object; and

commanding the telescope system to actuate the motors so as to point the telescope at the desired object.

37. The method according to claim 36, further comprising:

reading a first set of arcuate positions from the respective positional reference indicators when the telescope is pointing at the desired viewing object;

evaluating the position of the desired viewing object in a viewing field of the telescope;

actuating the motors so as to position the desired viewing object in a central region of the viewing field;

reading a second set of arcuate positions from the respective positional reference indicators when the desired viewing object is positioned in the central region of the viewing field; and

processing the first and second sets of arcuate positions so as to refine the virtual coordinate location of the telescope system with respect to the spherical coordinate system.

38. The method according to claim 37, wherein the first coordinate system is a rectangular coordinate system, the orthogonal telescope axes defining an alt-azimuth mount configuration, and wherein the spherical coordinate system is a celestial coordinate system, a celestial coordinate defined by a right ascension and a declination.

39. The method according to claim 38, wherein the rotation metric aligns a virtual right ascension of the telescope with a right ascension of the celestial coordinate system.

40. The method according to claim 39, wherein the rotation metric corresponds to time.

41. The method according to claim 38, wherein the position reference indicators comprise encoders coupled to their respective axes, each encoder defining an arcuate displacement of the telescope about its respective axis.

42. The method according to claim 41, wherein the first reference position is a determinable angle with respect to North, and wherein the second reference position is a determinable angle with respect to horizontal.

43. The method according to claim 42, wherein the first reference position is substantially North, and wherein the second reference position is substantially horizontal.

44. In an automated alt-azimuth telescope system where orthogonal altitude and azimuth axes define a first earth-based coordinate system, a method for orienting the telescope system with respect to a celestial coordinate system comprising:

providing altitude and azimuth motors, each motor coupled to rotate the telescope about its respective axis;

providing altitude and azimuth axial rotation indicators, each coupled to its respective axis and each outputting a rotational datum indicating an amount of telescope rotation about the respective axis;

providing a control processor;

inputting a geographical indicia into the control processor;

rotating the telescope about the azimuth axis to an azimuth reference index;

reading and recording the azimuth rotational datum corresponding to the azimuth reference index output by the azimuth axial rotation indicator;

rotating the telescope about the altitude axis to an altitude reference index;

reading and recording the altitude rotational datum corresponding to the altitude reference output by the azimuth axial rotation indicator; and

processing the geographical indicia and the azimuth and altitude rotational data to translate between the earth-based coordinate system into the celestial coordinate system.

45. The method according to claim 44, further comprising:

identifying, to the control processor, a celestial coordinate of a first desired viewing object, the control processor translating said celestial coordinate into a set of desired rotational data with respect to the azimuth and altitude reference positions, such that when each respective axial

rotation indicator outputs the desired rotational datum, the telescope is pointing substantially at said desired viewing object; and

commanding the telescope system to actuate the motors so as to point the telescope at the desired object.

46. The method according to claim 45, further comprising:

evaluating the position of the first desired viewing object in a viewing field of the telescope;

actuating the motors to reposition the desired viewing object in a central region of the viewing field; and

updating the altitude and azimuth rotational data so as to refine the translation between the earth-based and the celestial coordinate systems.

47. The method according to claim 46, further comprising:

identifying, to the control processor, a celestial coordinate of a second desired viewing object, the control processor translating said celestial coordinate into a set of desired rotational data with respect to the azimuth and altitude reference positions, such that when each respective axial rotation indicator outputs the desired rotational datum, the telescope is pointing substantially at said second desired viewing object; and

commanding the telescope system to actuate the motors so as to point the telescope at the second desired object.

48 The method according to claim 47, wherein the evaluating and updating steps are repeated for the second desired viewing object, so as to further refine the translation between the earth-based and the celestial coordinate systems.

49. An automated telescope system including:

a telescope tube having a major longitudinal axis; and

an MR sensor disposed along the major axis of the telescope tube, the MR sensor configured to provide an indication signal when the telescope is pointing in a particular direction relative to a predefined compass point.

50. The fully automated telescope system according to claim 49, wherein the MR sensor is coupled to a communication bus, the MR sensor providing indication signals to a command module, the command module translating said indication signals into motor control signals suitable for transmission to a motor module, the motor module processing said motor control signals into motor motion commands, such that the telescope is automatically positioned in the particular direction relative to the predefined compass point in operative response to the indication signals.

51. An illumination source for providing uniform illumination to an LCD display screen, the illumination source comprising:

a cusped, curvilinear light box positioned beneath the display screen, the cusp bisecting the light box and disposed substantially midway between opposing ends of the light box; and

a plurality of light sources configured to shine into the light box in the direction of the cusp, wherein each arcuate portion of the cusp diffuses light and directs it onto the display screen at a substantially constant scattering angle with respect to the light sources.

52. The illumination source according to claim 51, wherein the light sources are light-emitting-diodes.

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~~53. The illumination source according~~ to claim 52, wherein the light box is constructed of a translucent material.

ABSTRACT

FULLY AUTOMATED TELESCOPE SYSTEM
WITH DISTRIBUTED INTELLIGENCE

A fully automated telescope system is able to be fully operable in both Alt-Az and polar configurations. In either configuration, the telescope aligns itself to the celestial coordinate system following a simplified initialization procedure during which the telescope tube is first pointed north and then pointed towards a user's horizon. A command processor, under application software program control orients the telescope system with respect to the celestial coordinate system given the initial directional inputs. The initial telescope orientation may be further refined by initially inputting a geographical location indicia, or by shooting one or two additional celestial objects. Once the telescope's orientation with respect to the celestial coordinate system is established, the telescope system will automatically move to and track any desired celestial object without further alignment invention by a user.

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